Passenger Route Choice and Assignment Model for Combined Fixed and Flexible Public Transport Systems

Jishnu Narayan
Oded Cats
Niels van Oort
Serge Hoogendoorn
Department of Transport and Planning
TU Delft

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SCRIPTS
(Smart Cities’ Responsive Intelligent Public Transport Systems)
Trends in public transport systems

1. Introduction
2. Literature gap and research question
3. Methodology
4. Integrated public transport route choice model
5. Application
6. Results
7. Conclusion

Traditional public transport

Emergence of Demand Responsive Services

Combined system improves overall efficiency

Need for new models to understand how users combine line/schedule based public transport services and demand responsive services?
Literature gap and research question

- Existing literature
  - Route choice modelling largely ignored
  - On-demand services modelled in isolation

- **Major research question**: Modelling the integrated route choice of users combining fixed and flexible public transport systems
Overview of the methodology

- Agent based simulation method
Integrated public transport route

1. Line/Schedule based services
   - Real time booking
   - Door-to-door services
   - Fleet of vehicles controlled by a central dispatching unit

2. Fixed PT

3. Flexible PT

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10. Conclusion
Integrated public transport route (1, 2, 3, and 4)

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Integrated public transport route choice model

- **Choice set generation**

  Consider an OD pair

  Define set $S_{OD}$

  Randomly select a stop pair from $S_{OD}$

  Assign legs to modes and store path

  Remove the pair from $S_{OD}$

  **Flowchart**

  - **No**
  - **Yes**

  Is $S_{OD}$ empty?

  **Stop**
Integrated public transport route choice model

• Scoring of choice alternatives

\[ U_i = \beta_{\text{walk/bike}}t_{\text{walk/bike}} + \beta_{\text{transfer}}N_{\text{transfer}} + \sum_{m=\text{fixedpt,flexiblept}} [\beta^m_{\text{wait}}t^m_{\text{wait}} + \beta^m_{\text{inveh.}}t^m_{\text{inveh.}} + \beta_{\text{money}}p^m.d^m] \]

• Assignment

\[ P(U_i) = \frac{(PS)_i.e^{U_i}}{\sum_{j=1}^{N} (PS)_j.e^{U_j}} \]
Case study

**Simulation setup**

**Test network:** Based on the city of **Sioux Falls** in the United States

**Modes available:** Car, Walk, Fixed PT, Flexible PT

**Implementation platform:** MATSim
## Simulation Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>User Choice</th>
<th>Car</th>
<th>Walk</th>
<th>Fixed PT only</th>
<th>Flexible + flexible PT</th>
<th>Flexible PT only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base scenario</strong></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>Fixed or flexible PT</strong></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td><strong>Fixed + flexible PT</strong></td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
## Market share

<table>
<thead>
<tr>
<th>Scenario</th>
<th>User Choice</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car (%)</td>
<td>Walk (%)</td>
<td>Fixed PT only (%)</td>
<td>Flexible + flexible PT (%)</td>
<td>Flexible PT only (%)</td>
</tr>
<tr>
<td>Base scenario</td>
<td>66</td>
<td>&lt;=1</td>
<td>33</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Fixed or flexible PT</td>
<td>62</td>
<td>&lt;=1</td>
<td>23</td>
<td>NA</td>
<td>15</td>
</tr>
<tr>
<td>Fixed + flexible PT</td>
<td>61</td>
<td>1</td>
<td>9</td>
<td>15</td>
<td>14</td>
</tr>
</tbody>
</table>

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Average waiting time vs fleet size

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Empty drive ratio vs fleet size

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Stay ratio vs fleet size

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Key findings

- This study developed a multimodal route choice and assignment model for combined Fixed and Flexible PT services
- The analysis showed that the mode share of Fixed PT + Flexible PT comes from the mode shift from Fixed PT
- The effect on waiting times of passengers by increasing fleet size is not pronounced beyond a certain point
- Fleet size of Flexible PT remains largely underutilized at higher fleet
Practical relevance and future direction

- **Practical relevance**: The model enables practitioners and policy makers to understand how users choose Fixed and Flexible PT services when operating under competition and cooperation

- **Future direction**: Implement model for network of Amsterdam ([Simulation visualisation](#))
  Developing a modelling framework to optimise Fixed and Flexible services
Thank you!

Mail: j.n.sreekantannair@tudelft.nl
Smart PT lab website: http://smartptlab.tudelft.nl/
Project: SCRIPTS